Paper No. 20

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

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Ex parte MICHAEL D. PERRY
and
BRENT C. STUART

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Appeal No. 2001-0238
Application No. 08/859,020

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ON BRIEF

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Before JEFFREY T. SMITH, PAWLIKOWSKI and MOORE, *Administrative Patent Judges*.

MOORE, *Administrative Patent Judge.*

DECISION ON APPEAL

This is an appeal under 35 U.S.C. § 134 from the final rejection of claims 1 - 11, which are all of the claims pending in this application.

REPRESENTATIVE CLAIMS

Claims 1, 2, 10 and 11 are representative of the claimed subject matter and read as follow:

1. A method for machining metals and alloys, comprising:

producing a pulsed laser output beam from a solid state laser, wherein said pulsed output beam comprises a plurality of

laser pulses wherein said laser pulses have a pulse repetition rate greater than 10 Hz and a wavelength in the range of 750 nm to 10.7 microns, wherein each pulse of said plurality of laser pulses has a pulse duration of 100 picosecond or less; and

directing said pulsed laser output beam onto a workpiece comprising metal or alloy, wherein each said pulse converts approximately greater than 0.1 micron to 1 micron of material of said workpiece from a solid state to a plasma state, wherein said material is removed from said workpiece by hydrodynamic expansion of said plasma.

2. A method for machining metals and alloys, comprising:

producing a laser beam from a solid state laser; and directing said laser beam onto a workpiece comprising material selected from a group consisting of metal and alloy, wherein said laser beam comprises a plurality of laser pulses, wherein said laser pulses have a pulse repetition rate greater than 10 Hz and a wavelength in the range of 750 nm to 10.7 microns, wherein each said pulse has a pulse duration within the range of 10 femtoseconds to 100 picoseconds and a focused irradiance of greater than 10^{12} W/cm^2, wherein each pulse of said plurality of laser pulses converts approximately greater than 0.1 micron to 1 micron of material of said workpiece from a solid state to a plasma state, wherein said material is removed from said workpiece by hydrodynamic expansion of said plasma.

10. An apparatus for machining metals and alloys, comprising:

a solid state laser for producing a pulsed laser output beam comprising a plurality of laser pulses wherein said laser pulses have a pulse repetition rate greater than 10 Hz and a wavelength in the range of 750 nm to 10.7 microns, wherein each said pulse of said plurality of laser pulses has a pulse duration of 100 picosecond or less; and

means for directing said pulsed laser output beam onto a workpiece comprising metal or alloy, wherein each said pulse converts approximately greater than 0.1 to 1 micron of material of said workpiece from a solid state to a plasma state, wherein said material is removed from said workpiece by hydrodynamic expansion of said plasma.

11. An apparatus for machining metals and alloys, comprising:

a solid state laser for producing a laser beam; and

means for directing said laser beam onto a workpiece comprising material selected from a group consisting of metal and alloy, wherein said laser beam comprises a plurality of laser pulses, wherein said laser pulses have a pulse repetition rate greater than 10 Hz and a wavelength in the range of 750 nm to 10.7 microns, wherein each said pulse of said plurality of laser pulses has a pulse duration within the range of 10 femtoseconds to 100 picoseconds and a focused irradiance of greater than 10^{12} W/cm^2, wherein each pulse of said plurality of laser pulses converts approximately greater than 0.1 micron to 1 micron of material of said workpiece from a solid state to a plasma state, wherein said material is removed from said workpiece by hydrodynamic expansion of said plasma.

The Reference

Pronko et al. "Machining of sub-micron holes using a femtosecond laser at 800 nm," Optics Communications, Vol. 114, pages 106-110, January 15, 1995. (Pronko).

The Rejection

Claims 1-11 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Pronko.

The Invention

The present invention is said to provide a method for laser cutting/machining of metals and alloys which achieves high machining speed with extreme precision, negligible heat affected zone, and no modification to the material surrounding the kerf. The method is accomplished by focusing a laser pulse of between 10 femtoseconds to 100 picoseconds onto a surface to produce an ionized plazma while the material to a depth of approximately 1

micon is unaffected by the removal of the material. (Appeal Brief, page 3, lines 5 - 15).

Discussion

I. Preliminary Matters

A. Non-Entry of Amendment

The appellants have attempted to appeal the decision of the examiner to not enter the amendment filed September 17, 1999. See, e.g. page 9, lines 2-3 and page 15, line 16 - page 16, line 10 of the Appeal Brief. This issue is not properly before this panel of the Board of Patent Appeals and Interferences; rather, it is a petitionable issue. We have no authority to review that decision. See In re Mindick, 371 F.2d 892, 894, 152 USPQ 566, 568 (CCPA 1967) (refusal of examiner to enter an amendment after final rejection of claims is a matter of discretion; if there is an abuse of discretion, the matter may be remedied by petition to the Commissioner of Patents; Board of Appeals does not consider the issue whether examiner's refusal to enter proposed amendment after final rejection constituted an abuse of discretion); In re Pavlecka, 319 F.2d 180, 188, 138 USPQ 118, 125 (CCPA 1963) (the non-entry of amendments is a procedural matter outside board's jurisdiction).

B. Priority Claim

The appellants have claimed priority to application serial no. 08/584,522 (now US Patent 5,720,894) in a new declaration, filed March 9, 1999 (see paper #8). The appellants assert that support for the claimed subject matter is found within the disclosure of that application and therefore Pronko is not available as prior art as they are able to swear behind Pronko. (Appeal Brief, page 9, line 17 – page 11, line 14).

The examiner states that nowhere in 5,720,894 is found a disclosure of a method or apparatus for machining metal or alloys nor support for removal of amounts of approximately greater than 0.1 micron to 1 micron. (Examiner's Answer, page 3, lines 16-20).

We have carefully reviewed the as-filed specification of application serial no. 08/584,522. At page 11, lines 7 – 19 the following passage is found:

> The description of the operation of the laser system with respect to dental applications is for exemplary purposes only and is not intended to limit the application of the laser of the present invention. As will be described in greater detail below, the laser system of the present invention has application to a wide variety of biological tissue removal processes as well as exceptional utility for general material removal and micro-machining. Those having skill in the art will immediately recognize the utility and applicability of the laser system's novel operational regime to laser-tissue interactions in the general sense.

At page 31, lines 4-16, the following passage is found:

> Although the ultrashort pulse duration high repetition rate laser system of the present invention has been described in

> connection with an exemplary dental drilling application, it will be clear to those having skill in the art that the laser system has operational characteristics that are suitable for a very wide range of material removal applications. For example, in the treatment of ear, nose, and throat disorders, volumetric material removal is required in various surgical procedures, such as middle ear bone surgery, cholesteatoma, skull and jaw bone surgery, selective removal of malignant tissue, and tympanic membrane surgery.
>
> Finally, at page 32, line 31 – page 33, line 3, we see:
>
> Those skilled in the art will appreciate that the foregoing examples and descriptions of various preferred embodiments of the present invention are merely illustrative of the invention as a whole, and that variations in wave length, pulse duration, pulse repetition rate, as well as beam energy density, may be made within the spirit and scope of the invention. Accordingly, the present invention is not limited to the specific embodiments described herein, but rather is defined by the scope of the appended claims.

The appellants assert that this disclosure in the parent case "described the use of the invention for general material removal and for micro-machining;" that the claims in the parent claimed the invention in a broad sense; and that all the parameters of the invention claimed in the application on appeal are shown in the parent application. (Appeal Brief, page 10, line 18 – page 11, line 4). We disagree.

Claim 1 has several recited features, including using a pulsed laser output beam from a solid state laser on a metal or alloy workpiece to oblate into plasma 0.1 to 1 micron of the metal or alloy by using a plurality of laser pulses which have a pulse repetition rate greater than 10 Hz and a wavelength in the

range of 750 nm to 10.7 microns, and each pulse has a pulse duration of 100 picosecond or less. While the parent application discloses various ranges or power structures for a pulsed laser, we are unable to find the essential claimed features here. The appellants have made no effort to point to support in the specification for the claimed subject matter, and our efforts have failed to find any support for the claimed invention. Accordingly, we agree with the examiner that the subject matter as claimed is entitled to a priority date of May 20, 1997.

Turning now to the declaration of Michael D. Perry, we note that it illustrates pages from laboratory notebooks recording measurements from experiments on December 11, 1993; December 12, 1993, January 8, 1994, January 11, 1994, and February 3, 1994. See, e.g. Declaration of Perry, page 2, line 5 – page 3, line 8. However, we note that none of this information is contained within the parent application (or, for that matter, the instant application). Furthermore, other than the statement that there were "extensive discussions" which led to "later work" which formed the basis for the parent application, there is no evidence whatsoever of due diligence to the filing date of the application, as required by 37 CFR § 1.131(b). Consequently, even were we to find the earlier filing date, the declaration would be

insufficient under Rule 131. Pronko, therefore, remains a valid reference.

II. The Rejection

The examiner has found that Pronko discloses a method of machining metals including producing a pulsed laser beam from a solid state laser at a repetition rate of 1 kHz, a wavelength of 800 nm and a pulse duration of from 150 femtoseconds to 10 picoseconds; directing the beam to a silver metal workpiece; and each pulse removing about 0.05 microns of material via hydrodynamic expansion of plasma. The examiner has also found that no damage occurs outside the heat affected zone of about 5.8 nm and the entire heat affected zone is removed; allowing no thermal transfer beyond the removal depth. (Paper #5, page 3, lines 4-12).

The examiner has also found that Pronko shows that greater amounts of material can be removed by using longer pulse widths, the examiner concludes that it would have been obvious to one of ordinary skill in the art at the time the invention was made to produce a removal depth per pulse of from 0.1 - 1 micron by employing a somewhat longer pulse width than the 200 femtosecond pulse illustrated by Pronko. The examiner also concludes that it would have been obvious to one skilled in the art at the time the invention was made to increase the beam energy to an irradiance

of 10^{12} W/cm^2 to speed machining or form deeper features as the material removal rate is proportionate to the beam energy. (Paper #5, page 3, lines 17 – 27).

The appellants counter that the claimed method results in the conversion of workpiece to plasma for any pulse duration less than 100 picoseconds, contrary to the logic that it would be necessary to increase the pulse width to produce an increase in material removal (Appeal Brief, page 12, lines 1 – 12). The reasoning is that Pronko is acting in a low power range (approximately 10^{10}-10^{11} W/cm^2) and only converting material to vapor, not plasma. According to the appellants, only a negligible additional amount of material can be removed by increasing the pulse width in the fully ionized plasma realm of 10^{12} W/cm^2, as the additional energy simply goes into the plasma. (Appeal Brief, page 12, line 13 – page 13, line 8).

Claims 1 and 10 contain, in terms of beam power, the limitation that each pulse converts approximately greater than 0.1 micron to 1 micron of material of said workpiece from a solid state to a plasma state, wherein said material is removed from said workpiece by hydrodynamic expansion of said plasma. Claims 2 and 11 require a focused irradiance of 10^{12} W/cm^2.

We find that the Pronko reference discloses the formation of plasma (page 107, column 1, line 4) during the laser oblation

process and that the optical emissions are proportional to the amount of material removed which is a function of incidence fluence (Id., column 1, lines 3-9).

However, Pronko discloses a system producing pulses with an energy of 300μJ (p. 106, column 1, line 19) focused on an area of ~6.0μm. In the examples, the pulses contain ~40 nJ (p. 108, column 2, line 16) or 250nJ (page 109, column 1, line 6). Both the examiner and the appellants appear to concur that these amounts are lower intensity ($< 10^{10}$-10^{11} W/cm^2)(Appeal Brief, page 12, lines 13-16)(about 1.4 x 10^{10} W/cm^2)(Paper #5, page 3, lines 15-16) than that required by claims 2 and 11 (10^{12} W/cm^2).

The minimum intensity of claims 1 and 10 is not expressly recited other than by the functional limitation of the requirement of hydrodynamic expansion of plasma. The specification submits that such values are typically 10^{14} W/cm^2 for 100 femtosecond pulses (page 13, lines 9-10) but also states that the minimum laser focused requirement is 10^{12} W/cm^2(page 8, lines 7-12). Consequently, we interpret claims 1 and 10 as also requiring a minimum focused laser irradiance of greater than 10^{12} W/cm^2.

The examiner is of the opinion that a simple power increase is obvious in order to form deeper features where needed, or to speed machining when using repetitive pulses at a single location

(Paper #5, page 3, last 4 lines). We disagree. The point of the Pronko reference is to demonstrate that the shorter pulse widths have a greater resolution for use in ablation (Pronko, page 106, column 1, first paragraph).

We are, therefore, unable to agree with the examiner's position that one of skill in the art would be motivated to increase the power by at least about a factor of 10 to speed machining, when the reference itself is concerned with the resolution of the ablation and the reduction of diffused heat. Consequently, we shall reverse this rejection.

REVERSED

JEFFREY T. SMITH Administrative Patent Judge	)
BEVERLY A. PAWLIKOWSKI Administrative Patent Judge	) BOARD OF PATENT) APPEALS AND) INTERFERENCES
JAMES T. MOORE Administrative Patent Judge	)

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